Development of a High Energy Density EV Cell

PI: Mohamed Alamgir

LG Chem Power / LG Chem

June 7, 2017

Project ID: ES331

"This presentation does not contain any proprietary, confidential, or otherwise restricted information"

Overview

Timeline

- Project Start: Feb 11, 2015
- Project End: Aug 28, 2018
- Percent complete: 52%

Budget

- Total project funding: $3.28 M
- DOE share: $1.64 M
- Contractor share: $1.64 M
- Funding for FY17: $0.85 M

Barriers

- Energy density
- Life
- Cost

Partners

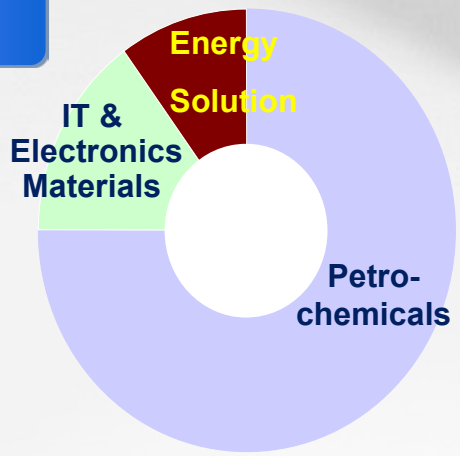
- LG Chem, INL, SNL, NREL
- Project lead: LGCPI

Objectives

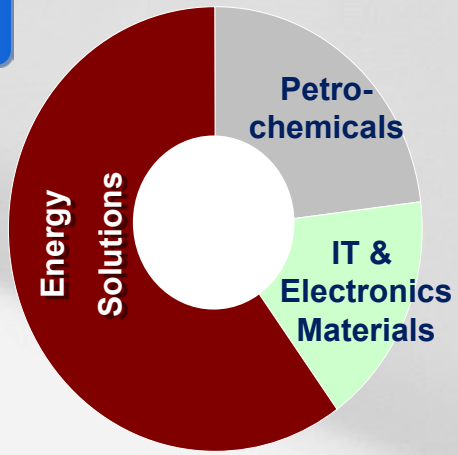
- **Develop a cell and module suitable for use in the 200-Mile USABC BEV program.**
- **Two key goals of the program are to meet the USABC cell level targets of 750 Wh/l and $100/kWh.**
- **The objective will be to employ next-generation high energy density cathodes such as layered-layered compounds and Si anodes.**
- **Deliver cells and modules to USABC for testing.**

LG Chem

Revenue



R&D Expense



Energy Solution

- Lithium-Ion Batteries for
  - Mobile Phone, Laptop, Power Tool
  - Hybrid & Electric Vehicles
  - ESS

Petrochemicals

- ABS/EP
- NCC/Polyolefin
- PVC/Rubber
- Acrylate

IT & Electronics Materials

- LCD Polarizer
- LCD Glass
- OLED Materials
- Color Filter

LGCPI

- Battery Pack Concepts, Design and Prototype Builds
- Battery Management Systems
- Sales and Customer Support

Troy, MI

Sales & Pack R&D

LGCMI

- $300M+ investment with ARRA funding
- Groundbreaking: Summer 2010
- In Production now

Holland, MI

Cell Manufacturing

USABC EV Cell Goals

Gap Chart			
End of Life Characteristics at 30°C	Units	System Level	Cell Level
Peak Discharge Power Density, 30 s Pulse	W/L	1000	1500
Peak Specific Discharge Power , 30 s Pulse	W/kg	470	700
Peak Specific Regen Power , 10 s Pulse	W/kg	200	300
Usable Energy Density @ C/3 Discharge Rate	Wh/L	500	750
Usable Specific Energy @ C/3 Discharge Rate	Wh/kg	235	350
Usable Energy @ C/3 Discharge Rate	kWh	45	N/A
Calendar Life	Years	15	15
DST Cycle Life	Cycles	1000	1000
Selling Price @ 100K units	$/kWh	125	100
Operating Environment	°C	-30 to +52	-30 to +52
Normal Recharge Time	Hours	< 7 Hours, J1772	< 7 Hours, J1772
High Rate Charge	Minutes	80% ΔSOC in 15 min	80% ΔSOC in 15 min
Maximum Operating Voltage	V	420	N/A
Minimum Operating Voltage	V	220	N/A
Peak Current, 30 s	A	400	400
Unassisted Operating at Low Temperature	%	> 70% Usable Energy @ C/3 Discharge rate at -20 °C	> 70% Usable Energy @ C/3 Discharge rate at -20 °C
Survival Temperature Range, 24 Hr	°C	-40 to+ 66	-40 to+ 66
Maximum Self-discharge	%/ month	< 1	< 1
* Cell operates between 4.6 and 2.4V; Operating SOC range: 95- 5%			
** At the system level			

Approach/Strategy

- **Study cathode/anode material properties to improve primarily energy density. Initial focus is on Mn-rich cathodes.**
- **Characterize and improve performance and life by optimizing electrode structures and electrolyte compositions.**
- **Develop low-cost module design that can ensure mechanical integrity of high energy density EV cells**

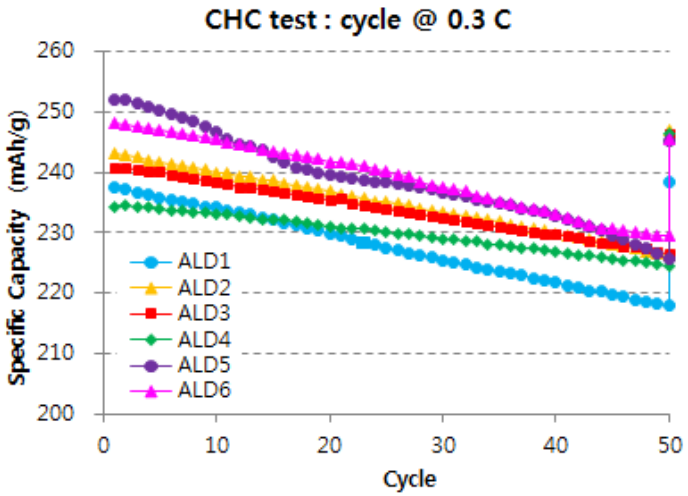
Technical Accomplishments/Results

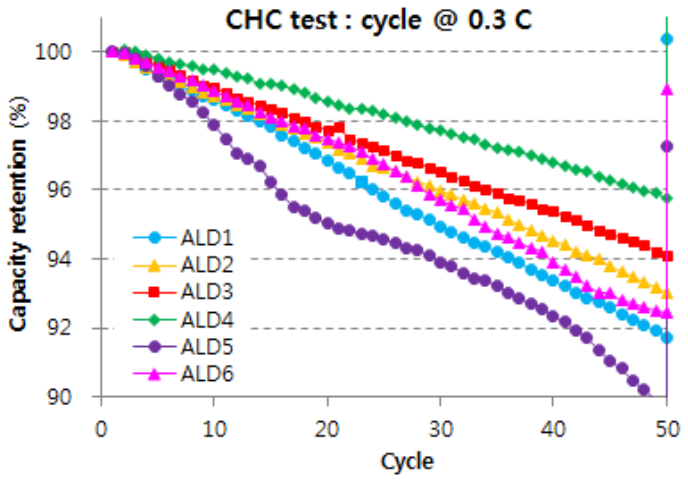
- **Studies were carried out to improve the durability of Mn-rich cathode materials using scaled-up ALD coating technologies**
- **Synthesis and characterization of doped Mn-rich cathode to improve cycle-life and voltage fade.**
- **Gassing remains an important issue for Mn-rich cathode materials especially when charged to high voltages.**
- **Comparative studies of Si-based anode materials such as SiO, Si alloy and Si-carbon composites. SiO demonstrates better cycle-life.**
- **Studies to develop high loading electrodes.**

Technical Accomplishments/Results

- **Studies to optimize Si-based anode materials including development of appropriate binders, conductive additives and electrolytes.**
- **Use of ALD coating on Ni-rich cathode leads to improved life.**
- **Studies of electrode structures with the goal of developing high loading electrodes.**
- **Three batches of cells have been fabricated and delivered to the USABC for testing.**

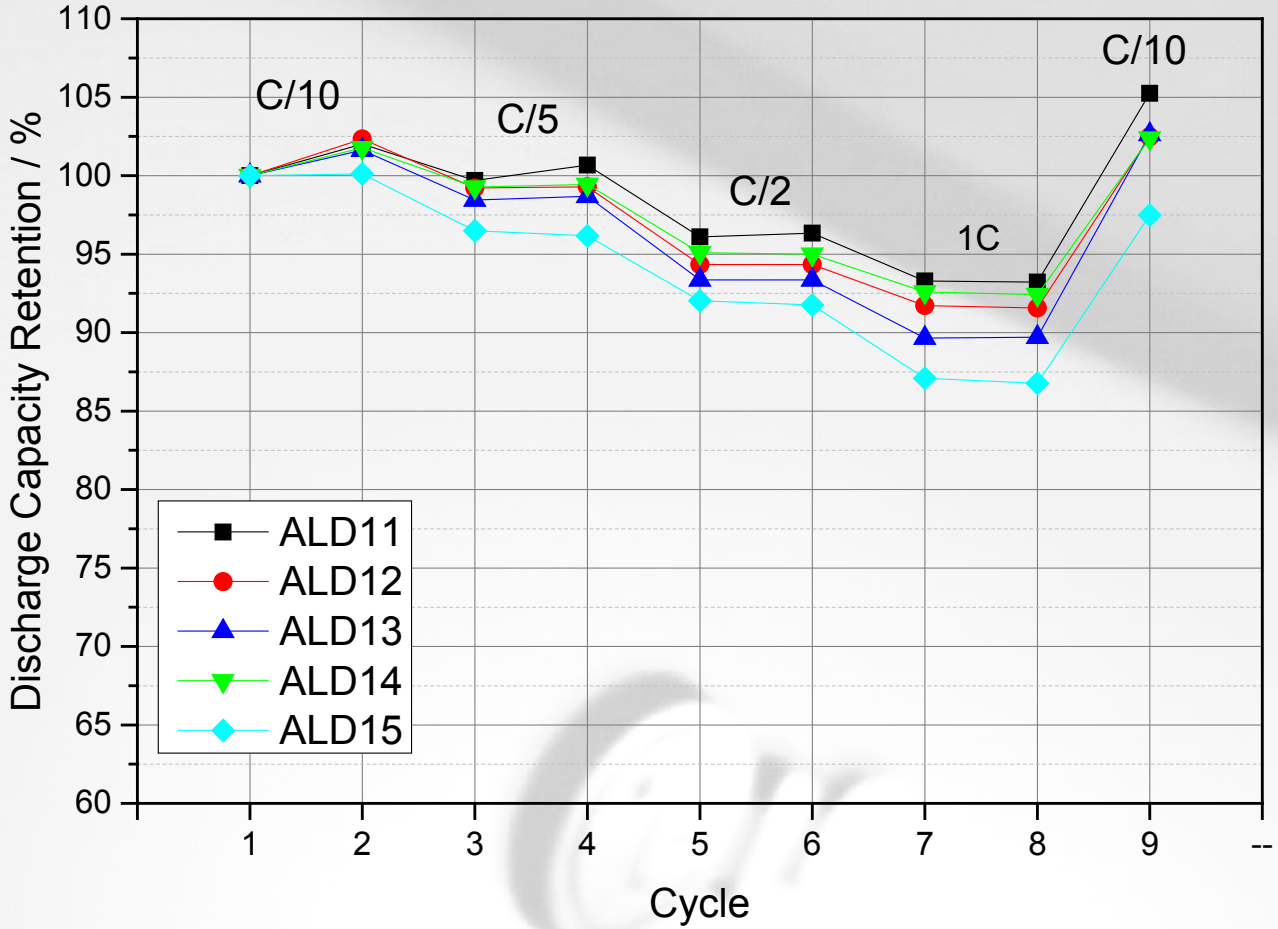
Results





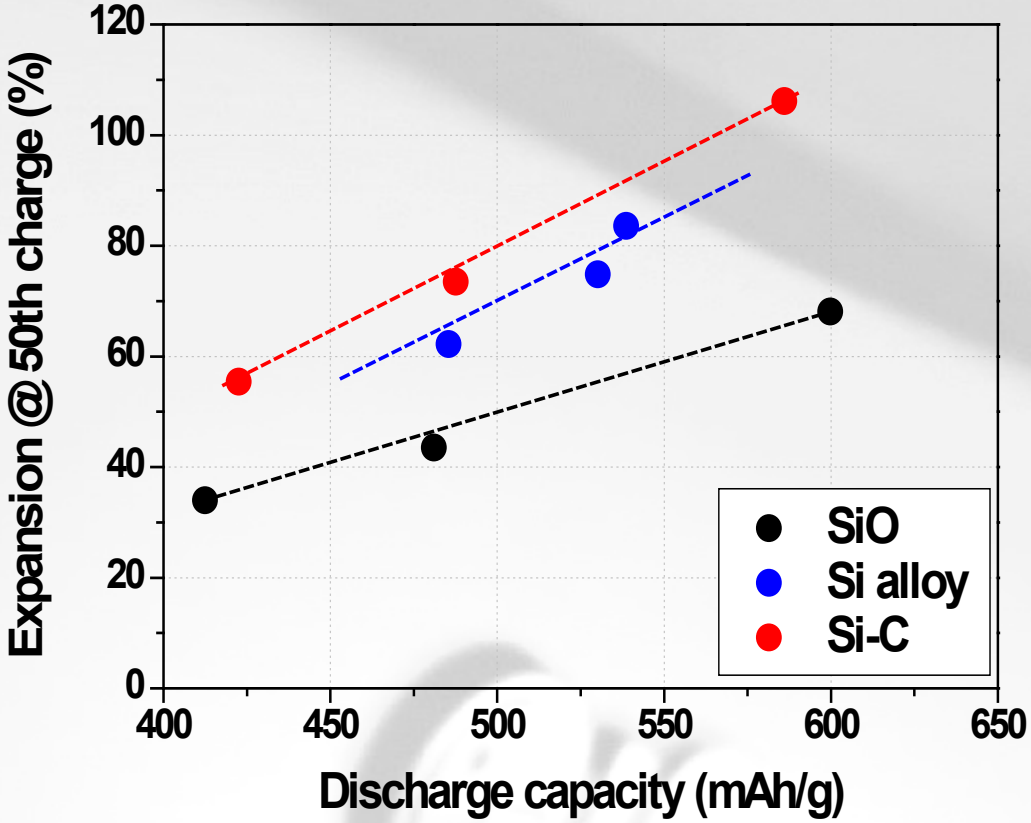
- **ALD coating improves the cycle-life of Mn-rich cathode. Thicker coatings enhance durability.**

Results- *continued……*



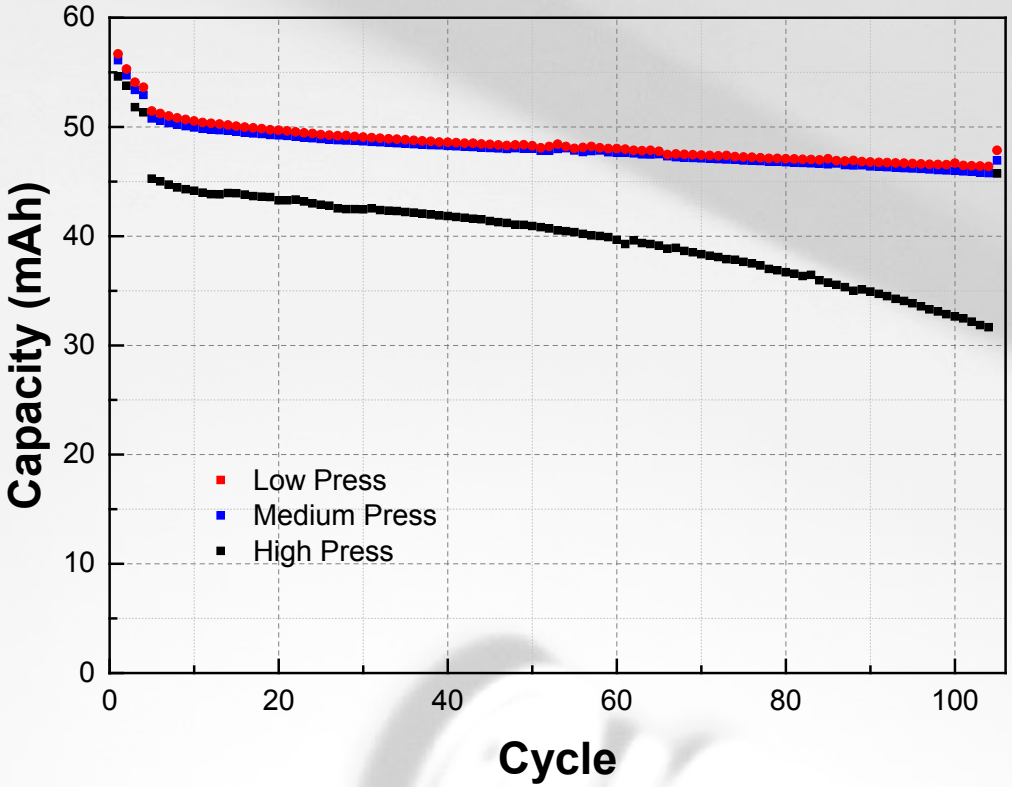
- **The larger the number of ALD coating, the lower is the rate capability.**

Results- *continued……*



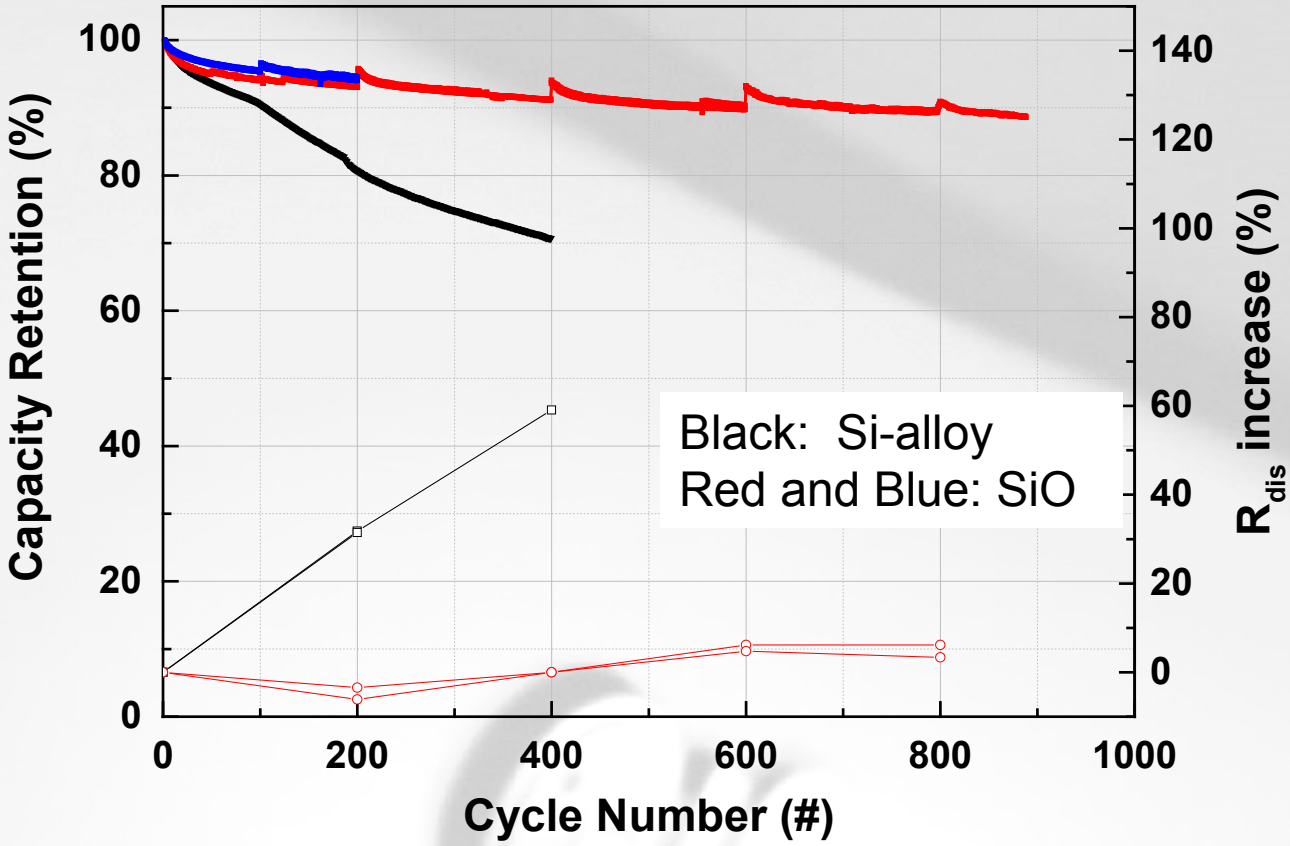
- **Comparison of the expansion of various Si-based electrodes. The data are for cells after the 50th charge.**

Results- *continued……*



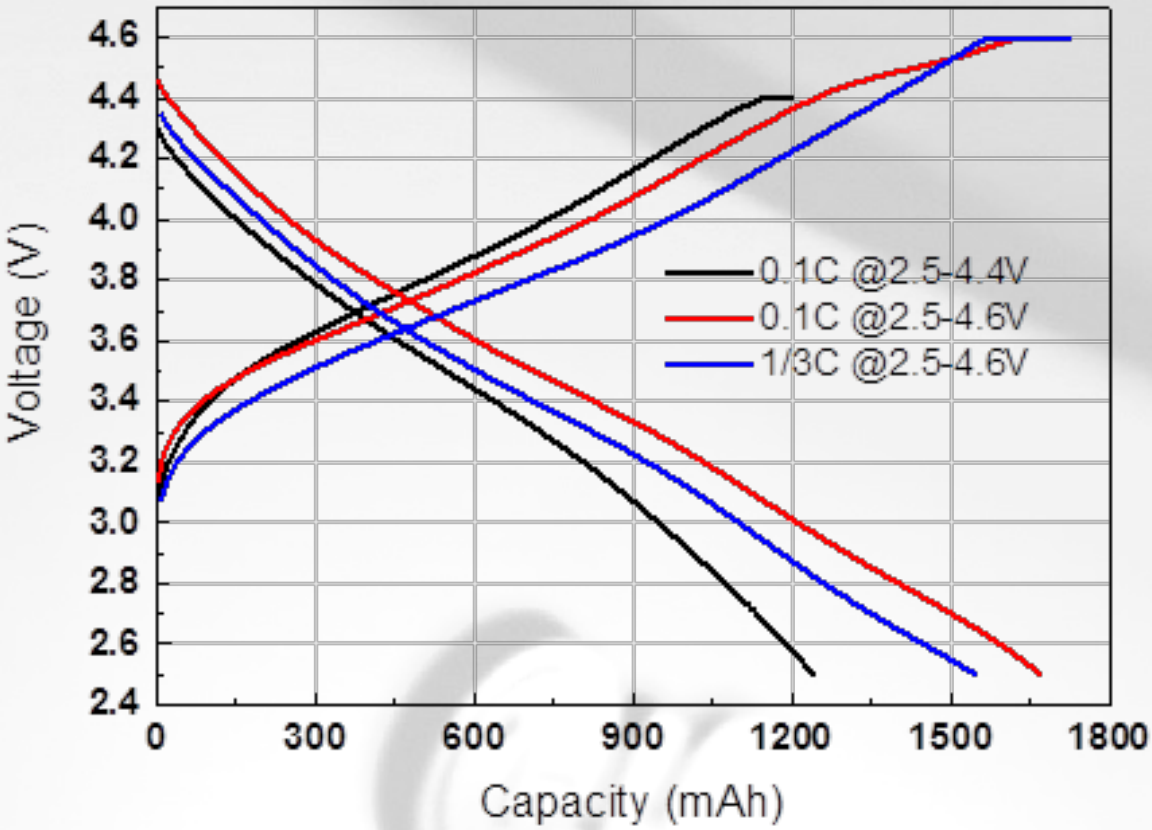
➢ **Effect of SiO electrode porosity on cycle-life.**

Results- *continued……*



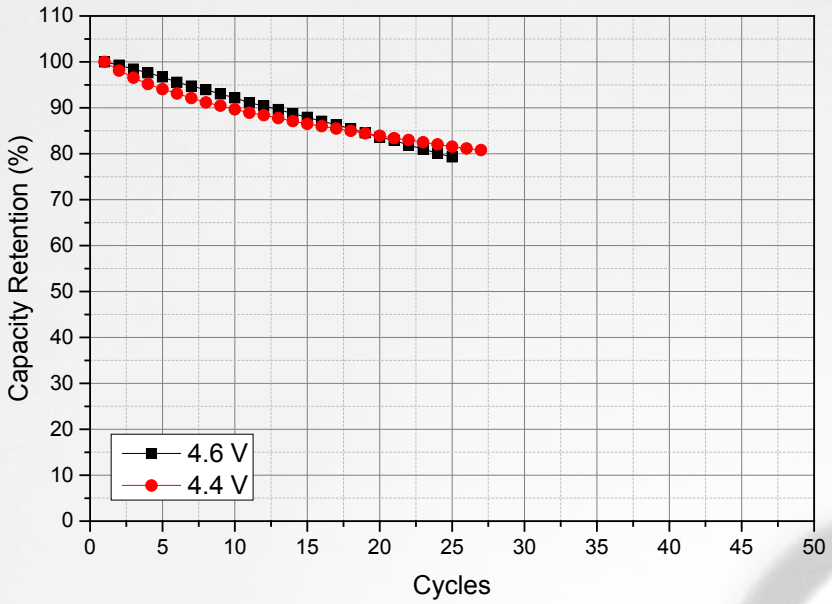
- **Comparison of the cycle-life of Si-alloy and SiO-based full cells at room temperature and 0.3C rate.**

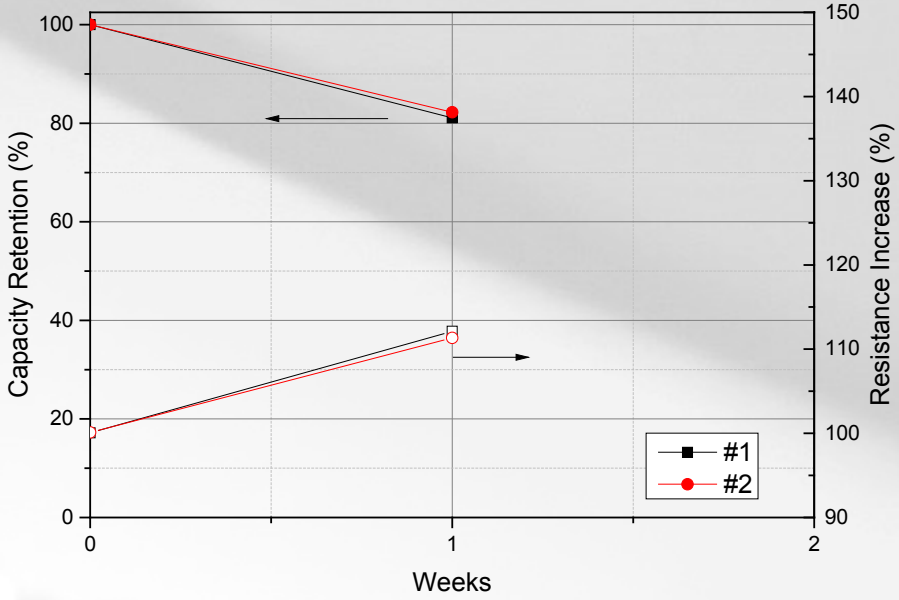
Results- *continued……*



- **Mn-rich cathode/Si anode cell: Effect of charge voltage on delivered capacity**

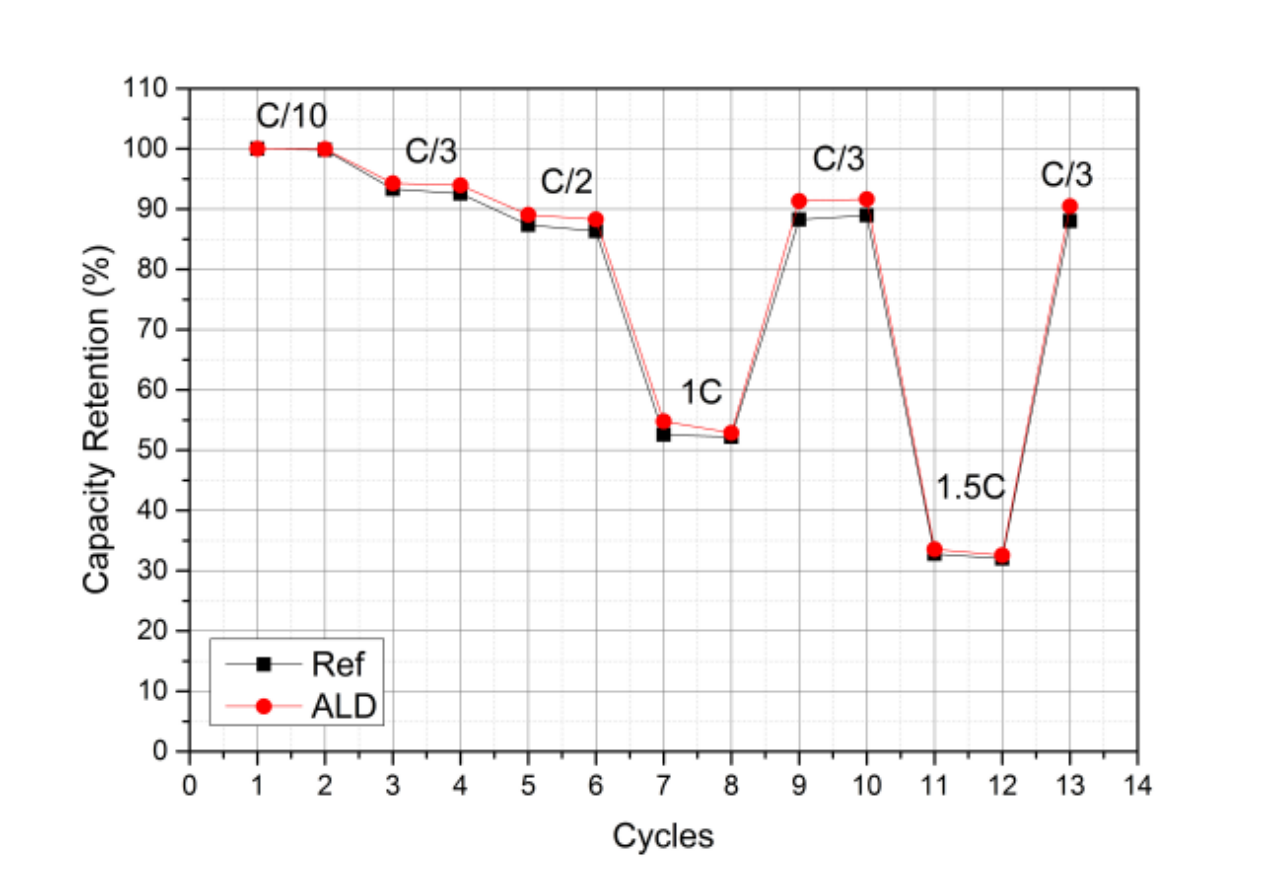
Results- *continued……*





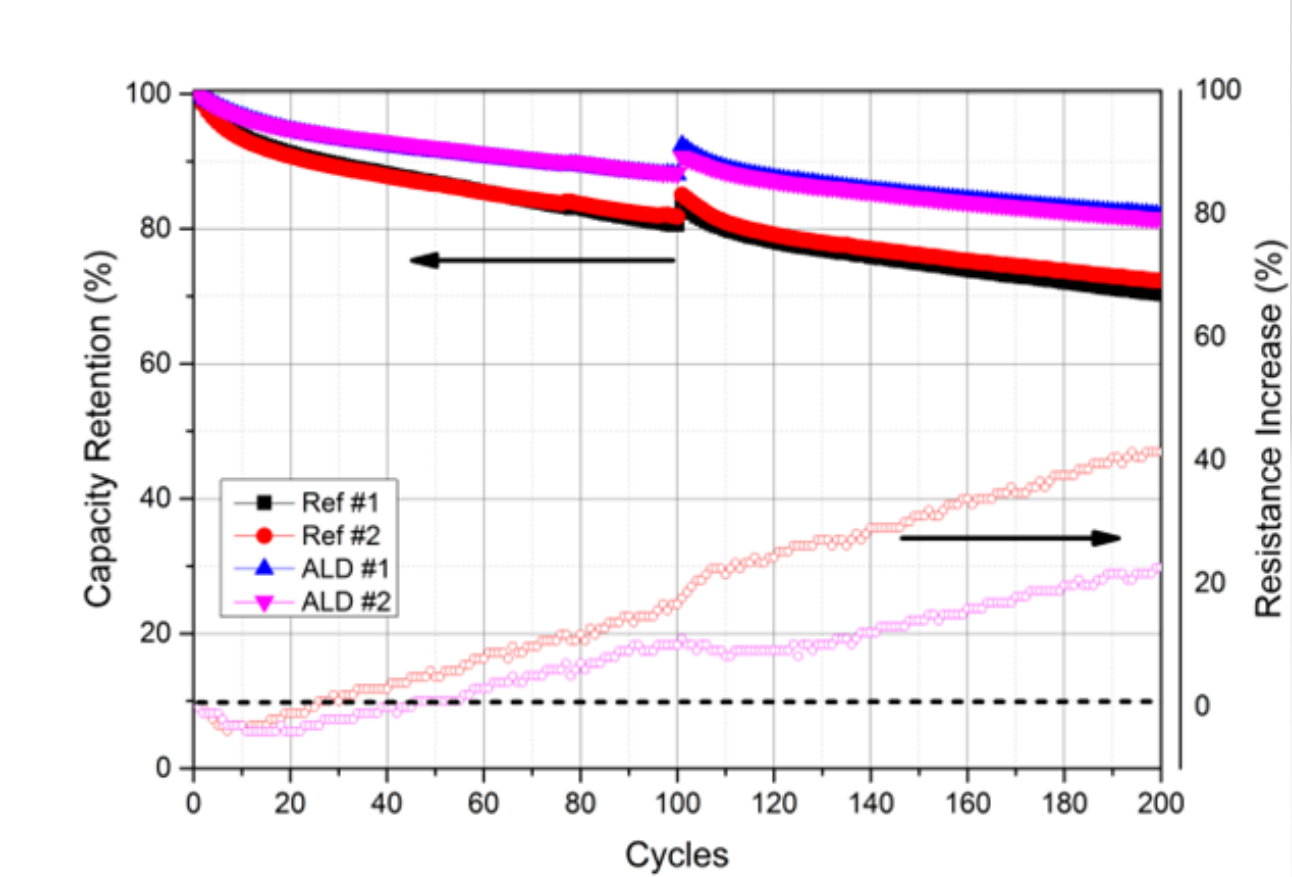
- **Left: cycle-life of the Mn-rich/high loading SiO cell at room temperature and C/3 discharge rate and C/10 charge rate**
- **Right) Storage at 60°C and 80% SOC.**

Results- *continued……*



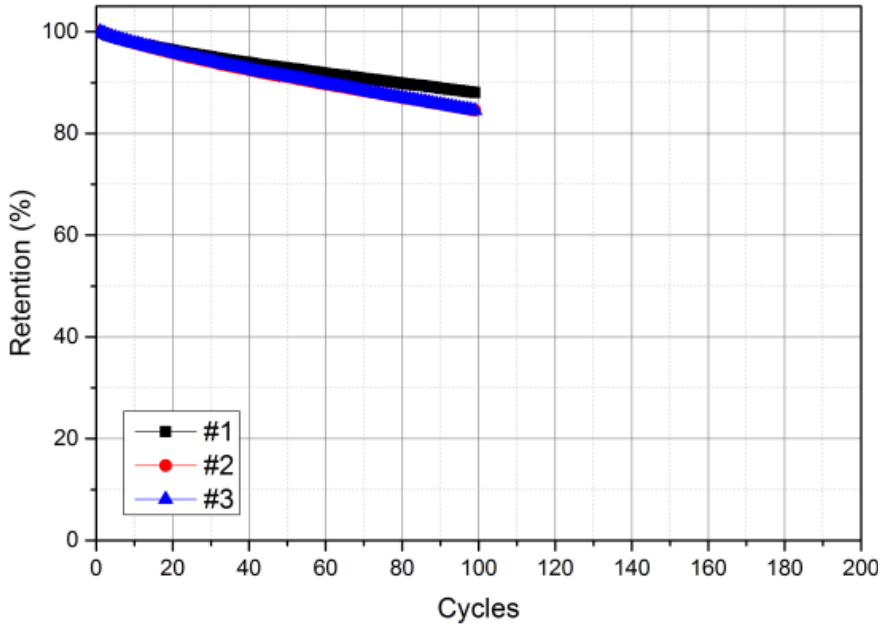
- **Rate Capability of ALD-coated Ni-rich cathode/graphite cells.**

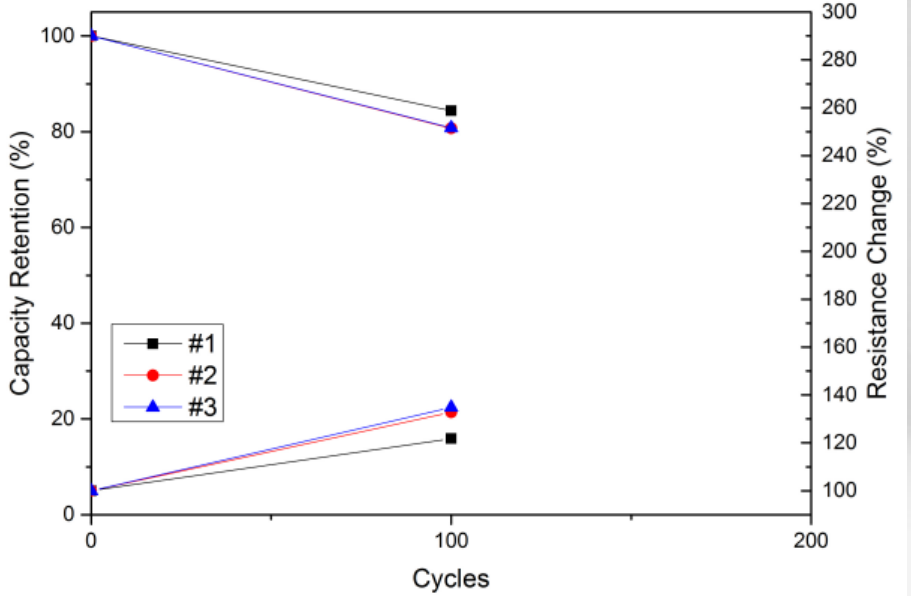
Results- *continued……*



- **ALD coating of Ni-rich cathode: Capacity retention and resistance increase during cycling between 2.5 and 4.2V at room temperature at C/3**

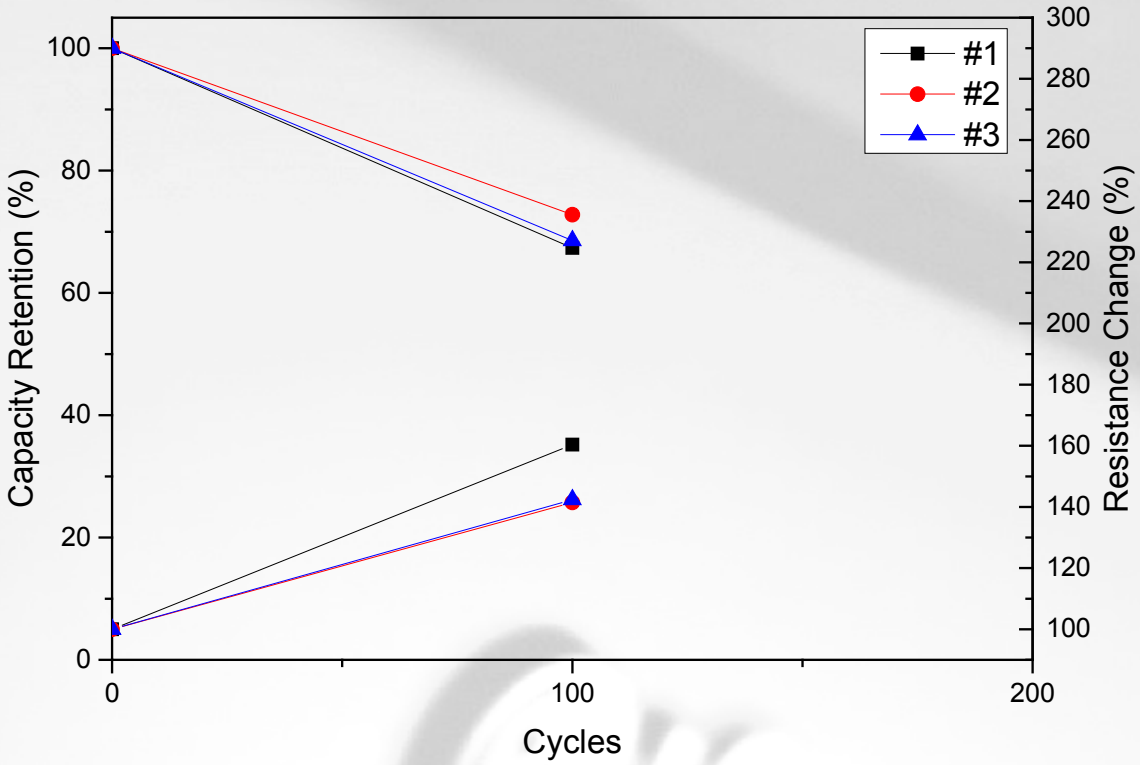
Results- *continued……*





- **Cycle-life results at 25°C for high loading Si-anode/Ni rich cells. Cells cycled between 2.5 and 4.2V at C/3.**

Results- *continued……*



- **Cycle-life results at 45°C for high loading Si-anode/Ni rich cells. Cells were cycled between 2.5 and 4.2V at C/3.**

Future Work

- **Focus on improving the energy density of the cell.**
  - **Material improvements (cell components)**
  - **Cell design optimizations**
- **Improve the durability of the SiO anode.**
- **Build and deliver large size EV cells to USABC.**

Any proposed future work is subject to change based on funding levels.

Acknowledgments

- **LG Chem:**
  - **Hoejin Hah, Janis Doelle, Sunkyu Kim and Seokkoo Kim**
- **USABC Team members (Chul Bae, Harshad Tataria, Jack Deppe, Carrie Okma, Lee Walker, Matt Keyser, Leigh Anna Steele)**
- **Financial support of USABC**